US ERA ARCHIVE DOCUMENT

op methods of environmental accounting using emergy llow the construction of combined emergy and monetary tatements and balance sheets for any human enterprise.

and economic methods as a means to develop integrated for evaluating public policies.

on spatially-explicit methods of emergy analysis that will ndices to meet their decision decision-making needs, often place-based and multi-scalar

r AED's expertise in Energy Systems Theory to help EPA, other state, federal, and private agencies and within untries of the world where this methodology is

4

as Theory (Odum 1983, 1994) was chosen as the best approach rated methods of analysis for evaluating the ecological, grated intention of analysis for evaluating the eCongran, so cial consequences of environmental policies. Energy is owledged as a common integrating factor in all phenomena in mratino of energy potentials is necessary for any action to the availability and use of energy potentials can be seen as the ving causal factor explaining all phenomena. Energy Systems ided a tested, self-consistent, systematic, and rigorous we needed for the development of integrated, comprehensive

ple recognize the importance of energy, few understand why not a sufficient basis for decision-making. Energies of lo different types of work within a system and therefore ha lues within the context of their networks. For example, a joule of ork done by a leaf cutting ant in the rainforest has a different the same amount of work done by an aborigine planting corn-ression is required to show the relative effects of these two nditures. Odum (1983) developed emergy to capture this

## Human Ecology Integrative Research Program: Environmental Accounting and Emergy Research (Ecological Research MYP)

Daniel Campbell, Sherry Brandt-Williams (St. Johns Water Management District), Tingting Cai (Immaculate Heart High School), Patricia Bradley, Maria Schneider (The Wooten Company), Andrew Ohrt (Delta Consultants, Inc.), Erika Felix (USEPA, Office of Waste Water Management), David Riposo (University of Maryland), Nicole Schuetz (The Pacific Forest Trust), and Hongfang Lu (South China Botanical Garden, Guangzhou, China)

The combination of mathematically rigorous energy systems diagrams for static and dynamic evaluations and modeling with the general environmental accounting methods using emergy (Odum 1996) provided us with a flexible platform for the development of indices and for integrated ecological and socioeconomic evaluation of policy alternatives in many different systems.

## Emergy, Some Formal Definitions

Emergy is all the available energy of one kind previously used up directly and indirectly to make a product or service. Its unit is the

The prefix em- is an acronym for energy memory. Emergy can use any kind of energy as the base, for example coal joules, solar joules, etc. However, in evaluating environmental systems, we commonly use solar energy (solar emjoule) as the base unit.

Solar transformity is the solar emergy required to make one joule of a product or service. Its units are solar emjoules per joule (sej T). The fundamental equation of emergy analysis is:

Emergy (sej) = Transformity (sejJ) X Available Energy (J)

From 2002 to 2007, research on the development and application of out with partners including the Canaan Valley Institute, a nonprofi out wan partners in Eurolang ne cananan vaney institute, a nonprosit proganization focused on improving the quality of life in West Virginia through improving the condition of watersheds, U.S. EPA Regions 3 and 4, the Nature Conservancy, NHEERL's Western and Mid-Continent Ecology Divisions, and ORD's National Risk Management Research

Component I – Large scale emergy analysis of states and regions and the further development of emironmental accounting and emergy methods. This work has focused on development of assessment methods to quantify emergy accounts for political and economic entities. Income statements and balnow sheets are completed or are being developed for 10 states (WV, MN, DE, MD, DE, NJ, PA, VA, CO, and RI). We are assupporting the development of the emergy methodology around the world, especially through collaborative work with Chinese scientists. AED is a partner in the NHEERL-NRMRL project to development indices of sustainability for the San Luis Valley, Colorado.

Component 2 - Spanial macetung ana emergy analysis of junascapes. This research has focused on the emergy analysis of landscapes, and has included the use of empower density (ED) as a predictor of coastal wethand condition and development of a new method for calculating a Landscape Development linensity Index (LDI), Working with the Offic of Water and the Minnescase Pollution Control Agency, the LDI was tested as a first order indicator of the condition of is obated wetlands in sota. Analysis of the Maryland landscape was begun this year to anding landscape patterns.

onent 3 - Comparison of emergy and economic methods. This arative emergy and economic benefit-cost streams affected by acid mine drainage in the r Cheat Watershed of West Virginia in partnership with the Canaan Valley Institute. As part of this effort, we developed the relationship Future research will examine the relationship between emergy nonmarket valuation methods and will explore the developme emergy-based trading scheme for environmental pollutants.

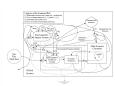


- new methods for documenting the emergy imported in goo
- 2) We quantitatively demonstrated a 2 to 1 net benefit rec

Major Findings and Accomplishments We have developed the theoretical basis for an emergy characterization of society's debt to the environment and

how it might be measured and paid off (see 3 Energy Systems diagrams below).

2) We are in the process of evaluating case studies that will

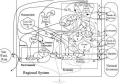


the LDI as a 1st Order Indicator of the Condition of Isolated Wetlan



2) We showed that the LDI is slightly better and cover as a 1<sup>st</sup> order landsc: estimator of isolated wetland c







tion and Network Analysis of Yancheng Biosphere Reserve

Major Findings and Accomplishment

Emergy Synthesis of Cobscook Bay

The available energy or exergy flowing on each pathway is shown along with the solar

required to the flux of available energy









### Major Findings and Accomplishment

- ted that as a general rule emergy value es environmental products in extraction is approached.
- 3) We accumulated evidence that energy systems theory can explain economic axioms and theories and that the two methods can be used together in integrated environmental

The AED's Emergy Research is developing a system of environmental accounting using emergy that is based on double entry bookkeeping and includes economic, environmental, and social emergy and monetary accounts. The bottom line of such a triple system of accounting is a direct measure of what is sustainable for any human enterprise. In addition, we are developing new emergy indices and strengthening the use of this methodology within the EPA and around the world with the goal of increasing our ability to make decisions on public policy alternatives that will result in increased well-being for the combined system of humanity and nature.

- Complete environmental accounting case studies and methods o allow resolution of emergy and monetary balance sheets. Compare emergy value with economic value as determined by non-market methods.
- 3. Further develop methods of measuring the contributions of the environment to society including the evaluation of ecosystem services using emergy methods and the evaluation of environmental liabilities and repayments (restoration) using the emergy accounting perspective.
- 4. Further develop methods to evaluate biodiversity





# Major Findings and Accomplishment.